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LABORATORY REPORT

FIRE HAZARD TO FALLOUT SHELTER OCCUPANTS:

A CLASSIFICATION GUIDE

by

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FINAL REPORT

FMRC SERIAL NO. 15328

APRIL 3, 1964

DEPARTMENT OF THE ARMY
OFFICE OF THE SECRETARY OF THE ARMY
OFFICE OF CIVIL DEFENSE
CONTRACT NO. OCD-PS-64-40
SUBTASK 1133A

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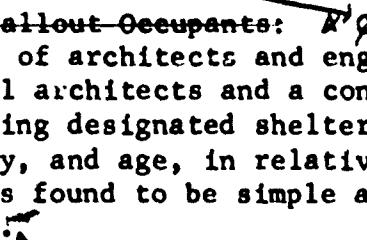
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ABSTRACT

A method of classifying the hazard from fire to occupants of fallout shelters is presented. It represents, in the form of a simple survey, a conservative fire-protection-engineering approach with a high confidence factor. The intention of this study is not to relate fire safety to weapons effects; instead it addresses the problem that should fires occur - from any cause - would the occupants of a particular fallout shelter be safe from fire? Further, the guide does not attempt to define the relative degrees of hazard, or probability of hazard, for non-sprinklered shelter buildings which are not unequivocally considered safe.

Assuming that fires from any cause have occurred following a nuclear attack; that there is no "fire storm"; that there will be no fire fighting by public fire department; that public water supplies and electric utilities will be in service; and that automatic sprinklers - as available - will be in service, the fire hazard to shelter occupants is analyzed. Safe separation distances between buildings were determined from British work and some conservative simplifying assumptions. *This*

A manual, "~~Fire Hazard to Fallout Occupants:~~ *A* Classification Guide," was prepared for the use of architects and engineers. The guide was field-tested by several architects and a consulting engineer. Trial surveys were made at existing designated shelters in buildings of varied construction, occupancy, and age, in relatively congested areas. ~~In general,~~ the guide was found to be simple and easy to use. Consistent results were obtained.



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I SUMMARY

A number of buildings in this country have been evaluated by architects and engineers as community fallout shelters against nuclear radiation. This report presents a method for evaluating the fire safety of shelter occupants in these buildings.

The classification method described represents a conservative fire protection engineering approach with a high confidence factor. It demonstrates the possibility of a simple survey for classifying fallout shelters for the protection they afford against fire. It was not the intention of this study to relate fire safety to weapons effects; instead it addresses the problem that given there are fires - from any cause - would the occupants of a particular fallout shelter be safe from fire? Further, the guide does not attempt to define the relative degrees of hazard or probability of hazard for those non-sprinklered shelter buildings which are not unequivocally considered safe.

A fire safety evaluation guide for architects and engineers is appended. The factors weighed are the combustibility of the shelter building, its contents, fire exposures from neighboring properties, and various fire protection features.

The format of the guide should minimize the evaluation work. The guide identifies fire-safe shelters and summarizes deficiencies.

II INTRODUCTION

Scope of Work

The appraisal of buildings in this country for protection of its citizens against radioactive fallout has resulted in the designation of many structures as community fallout shelters. The very nature of the hazard for which this protection was sought makes it imperative that people be confined to the shelter during a fallout emergency. The confining of people in buildings during a fire, which might break out during such an emergency, is contrary to usual practice. Emphasis has always been on the evacuation of people from burning buildings.

Because of the fact that people must remain in a shelter, such shelter buildings should be fire-safe for people. Consequently, a study has been made "...to develop a fire safety to life classification guide for fallout shelters in buildings...". Specifically, the scope of work was to, "1. Develop and test a method for evaluating the degree of safety to occupants of fallout shelters within buildings in the event of fires which might follow a nuclear attack and indicating proposed modifications to buildings which would minimize the danger to occupants from fire" and "2. Prepare an operational guide for field use of the method developed in the OCD Shelter Survey Program." This

study was conducted for the Shelter Research Division of the Research Directorate of the Office of Civil Defense. It is intended that this guide be suitable for the use of architects and engineers to enable them to arrive at a proper evaluation.

The basic purpose of this guide is to separate safe and unsafe shelters as found. Experience in providing protection for buildings has shown that, for design in improvement of protection, dependence cannot be placed on written general standards. Each situation must be viewed as it exists and solutions worked out for each particular case.

III DISCUSSION

A Assumptions

Several assumptions have been made in the preparation of this guide. These are:

1. Fires are assumed to have occurred from any causes following a nuclear attack.
2. Shelters and shelter buildings will not have sustained damage, other than possibly broken windows.
3. The shelter is not located in a "fire storm" area. That is, an area where many fires have broken out simultaneously throughout an extensive region of closely spaced combustible buildings. Such an area would very likely be uninhabitable because of oxygen deficiency and toxic gases.
4. There will be no fire fighting by public fire departments.
5. Public water supplies and electric utilities will be in service.
6. Automatic sprinkler systems, as available, will be in service.
7. Occupants of shelter areas will make periodic fire inspection tours of the shelter building; and in addition, responsible personnel will be familiar with fire-fighting equipment, including operation of automatically and manually controlled sprinkler systems.

B General Approach

In order to evaluate the fire safety of a shelter, it seemed advisable to separate the exposures to occupants into several components. These components consist of three areas and are designated by zones. The first, Zone 1, is the area actually occupied by the people; the second, Zone 2, is the area consisting of the shelter building, i.e., the structure housing the shelter area; the third, Zone 3, is the property external to and exposing the shelter building (Zone 2).

C Limitations

Zone 1 is not included in the evaluation of the shelter at the request of the Office of Civil Defense under the reasoning that as the shelter area will be continuously occupied and under constant surveillance, any fire would be quickly discovered and could be handled by the occupants using manual fire fighting equipment.

Factors affecting the habitability of a shelter are heat, smoke, lack of oxygen, and toxic or irritating gases. Although thresholds have been generally established for carbon monoxide inhalation and anoxia, there is little knowledge of the effects of a great number of toxic or irritating gases on people. Because of this, the guide tends to be conservative in its approach. The evolution of gases is dependent on several factors including kinds and amounts of combustibles; many of these are not well understood and it would be extremely difficult, if not impossible, to acquaint the analyst making the survey with all the variables involved. This, too, supports the conservative approach.

D Development of Zone 2 Rating

The analysis of the fire hazard of Zone 2 is based on accepted fire protection concepts. These are that where either combustible occupancy or construction is present, a fire is possible and fire suppression in the form of automatic sprinkler protection is necessary. The lack of sprinklers where the above conditions exist makes a shelter unacceptable. Where there is the possibility of a fire which would seriously challenge automatic sprinkler protection due to a congested occupancy or flammable liquid hazards, defined as an extra hazard occupancy, the shelter is classed as unacceptable. There are two reasons for this. The first is that such an occupancy would severely expose occupants to fire gases, and the second is that sprinkler systems in most cases would have to be especially designed for the occupancy. Sprinkler systems may have been so designed, but adequacy of the system would be difficult for the analyst to determine.

There is one other condition for Zone 2 which makes a shelter unacceptable. This is where the shelter building has a combustible roof deck with a combustible roof covering, regardless of whether sprinkler protection is provided. In the absence of public fire department activity, there is no protection from ignition caused by flying brands from a neighboring burning building. Such ignition could readily involve the entire combustible roof of a shelter building which would probably result in operation of all sprinklers under the roof and overtax water supplies for sprinklers, rendering the system ineffectual.

Factors which influence the rating of a shelter where Zone 2 has combustible construction or occupancy but do not make it unacceptable are the reliability of water supplies to automatic sprinklers and the presence of enclosures for stairways and elevators. The more important of these is water supply reliability. A malfunction of the public water system would very probably be unremedied during a fallout emergency. Thus, a water supply normally available in the event of a public water system failure causes a shelter to attain a higher degree of acceptability. Enclosures for vertical openings in Zone 2 which would inhibit heat transfer from story to story and possibly limit the number of operating sprinklers will also enhance the acceptability.

E Development of Zone 3 Rating

During a normal fire emergency, i.e., without the fallout problem, the probability of fire spread, especially in urban areas, is a function of combustibility of buildings and their contents, spacing of buildings with respect to one another, performance of the public fire department, and adequacy of water supplies. There are other factors, of course, such as weather conditions, topography and individual building protective features such as fire walls.

The preparation of the guide was done assuming no fire fighting by fire departments because of fallout. Consequently, this fire fighting is not a factor in preventing fire spread.

The most important single factor in the mechanics of fire spread from building to building is heat radiation. It is considered reasonable to simplify the fire spread problem by considering this the only factor. Therefore, the only factors influencing fire spread are considered to be spacing between buildings, combustibility of buildings and their contents, and physical barriers such as fire walls and wired glass in metal sash windows.

Experiments have been carried out at the Joint Fire Research Organization of Great Britain to measure the intensities of heat radiation likely to be encountered from fires for different ventilation conditions and different amounts of combustible materials. It was found that for a fire load (total amount of combustibles) of 8 lb. per square foot or greater, the radiating intensity tends to an upper limit of 4 calories per square centimeter per second. With a maximum fire load of 5 lb. per square foot, the radiation intensity is about 2 calories per square centimeter per second.* The span from 5 to 3 lb. per square foot is small, and only low or high fire loads are considered in evaluating Zone 3 exposures. Many of the examples of "high fire load occupancies" given in the glossary and applying to Zone 3 are considered as "ordinary hazard occupancies" when present in Zone 2. Justification is based on the prompt discovery of fire through continuous fire inspection tours of Zone 2 and the assumption that, for acceptability, Zone 2 will have automatic sprinkler protection where there are combustibles.

The intensity of 4 calories per square centimeter per second corresponds to a temperature of 1100°C. While ventilation affects the intensity, fire tests show that, regardless of the size of fire area, one window 5 ft. x 10 ft. can provide sufficient ventilation so that a 1100°C temperature can be attained. This situation would exist for most buildings. With fully ventilated fires, the radiating intensity depends on the fire loading as above described.

Pilot ignition, that is ignition of decomposition gases by a small flame one-half inch from a combustible surface, for kiln-dried wood occurs for incident intensities above 0.3 calories per square centimeter per second. Such ignition is possible with flying brands or sparks. Wood was chosen since it is the most commonly found combustible material on the exterior of buildings and since its behavior to heat radiation exposure is representative of a large variety of cellulosic building materials.

Calculations of separation distances necessary to prevent fire spread between buildings is based then on radiant intensities of 2 or 4 calories per square centimeter per second for low or high fire loadings respectively, and a permissible incident intensity for pilot ignition of 0.3 calories per square centimeter per second. This, the most modern approach, is proposed by the report "Heat Radiation from Fires and Building Separation" by Margaret Law. These radiant intensities are not comparable to those associated with thermal radiation from nuclear weapon detonations because of the latter's extremely short duration.

* Law, Margaret "Heat Radiation from Fires and Building Separation", Fire Research Technical Paper No. 5, London, 1963, pgs. 4-6.

A factor which determines the performance of a burning building as a radiator, in addition to the fire loading, is the per cent of window openings in the exposing wall. Two assumptions are made to simplify the use of this guide. One is that a building having combustible floors or roof will effectively have 100% window openings in the wall exposing the shelter building, Zone 2. The other is that a noncombustible building will have 50% effective window openings acting as a radiator. While these assumptions are not entirely valid, there certainly appears to be justification for them. In the case of the assumed 100% window openings, it would appear that fire spread in a building having combustible floors would proceed vertically very rapidly and the flame height above the roof would add considerably to the radiation intensity. In the case of the assumed 50% window openings, it would appear flames would be contained to a great extent within a noncombustible building. Noncombustible buildings having "window walls" normally have office type occupancies with relatively light fire loadings which would compensate for the greater radiator area.

Plain glass windows can absorb 40 to 60% of the radiation from a building fire, but thermal stresses in the glass place doubt in its integrity. Wired glass in metal sash windows, however, would be expected to stay in place. Consequently, credit for 60% radiation absorption has been given to its use in calculating separation distances. Where calculated distances between buildings are less than those permissible with wired glass, all openings in the shelter building wall must be eliminated or protected by fire doors or shutters.

An arbitrary limiting distance of 400 ft. has been set for exposing buildings which may radiate to a shelter building. Beyond this distance, heat radiation will not be serious. This distance is based on a building having combustible floor and roof construction with a radiating wall 1000 ft. long and 75 ft. high and having a fire load greater than 5 lb. per square foot.

Admittedly there are errors in calculating building separation distances by the above method. For example, it is assumed that wood exposed to heat radiation is kiln-dried. Such would rarely be true since there would nearly always be moisture present. Thus, this factor results in a conservative approach. On the other side of the picture, wind is not considered, and the Margaret Law report assumes public fire department response in 10 minutes. With the present lack of knowledge on fire spread, particularly with respect to conflagrations, the method used for setting up this guide is considered the best available at this time.

F Testing of Method

The "Fire Hazard to Fallout Shelter Occupants: A Classification Guide" was field tested by several architects and a consulting engineer. In general, the guide was found simple and easy to use; and consistent results were obtained.

Trial surveys were made at existing designated shelters having both combustible and noncombustible construction as well as varied combustible and noncombustible occupancies. Buildings visited were both old and new; but all were in relatively congested areas, presenting a challenge to the analysts. The guide used is attached as an appendix to this report.

IV CONCLUSIONS

The use of this guide should result in reasonably accurate appraisals of the fire hazard to fallout shelter occupants. It is expected that 100% performance will be unattainable because of the many variables involved in the evaluation. Value judgments relative to combustibility of materials and their arrangement favoring fire spread must be made. Many situations will be obvious while others would tax the judgment of the most experienced fire protection engineer.

V RECOMMENDATIONS

A great deal of work must be done to determine the habitability of a building exposed by other burning buildings. The influx of fire gases along with heat is an indeterminate factor.

Very limited knowledge exists of fire spread from building to building, particularly in conflagration situations. This study indicates considerable research would be desirable in this area.

RMN:jb

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ORIGINAL DATA : Filed with Contract Folder

ATTACHED : 38 Appendix Sheets

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FIRE HAZARD TO FALLOUT SHELTER OCCUPANTS:

A CLASSIFICATION GUIDE

The object of this guide is to make it possible for architect and engineers to evaluate the fire hazard of community fallout shelters. The hazard to confined personnel is the only consideration.

The approach to preparation of the forms making up the survey was to consider three basic areas or zones affecting the shelter-area proper. The zones are: (1) shelter area; (2) building housing the shelter area; and (3) properties nearby, defined as exposure, which might constitute a fire hazard to the building being considered. The fire hazard of Zone 1, shelter-area proper, is outside the scope of this guide and is not to be evaluated.

There will be cases where shelter areas are located in both basement or subbasement areas as well as in above-grade or upper-story areas. Where such co-existence occurs, it will be necessary in most instances to prepare separate surveys for each location.

The various analysis sheets are relatively self-explanatory. However, their use is explained in some detail on subsequent pages. Where automatic sprinkler systems are present, it means sufficient sprinklers are provided where needed for combustible construction or occupancy.

Zone 3, exposure, is based on fire loading in exposing buildings and the radiant heat energy the exposing buildings will transmit. Fire loadings are considered to give radiant heat intensities of 4 and 2 calories per square centimeter per second for high and low classifications, respectively. Permissible intensity received by the building housing the shelter area is considered to be 0.3 calories per square centimeter per second, or that necessary to cause the ignition of wood when a flame is near the wood surface (pilot ignition). Protection factors outlined in the analysis sheets are based on reducing intensity below the above limit or preventing ignition sources in the form of flying brands from entering a shelter building.

The analyst should bear in mind that radiant heat energy travels in the same manner as light. Thus, radiant heat affecting the shelter building will come from what the shelter building can "see". Consequently, the upper stories of an exposing building which is one building removed would often have to be considered (see Exhibit C).

In considering various protection factors for exposure, no credit has been given to the provision of outside sprinklers designed to act as a water curtain for window openings. This has been done because of the lack of confidence in water supplies for these sprinklers, and the fact that normally manual control is necessary.

It is possible for a shelter, even in some special cases of severe exposure, to be reasonably fire safe providing the shelter is below grade and certain conditions are met.

In considering exposures, the analyst should consider noncombustible buildings with noncombustible occupancies as no exposure. In this special case, no evaluation of the exposure is necessary.

Use Sanborn maps, available from insurance as well as some public libraries in the larger cities, in determining the nature of exposures. Consult public fire department officials where the analyst may not be able to determine fire loadings of exposing buildings.

The grading system is based on several assumptions. These are:

1. Fires are assumed to have occurred from any causes following a nuclear attack.
2. Shelters and shelter buildings will not have sustained damage, other than possibly broken windows.
3. The shelter is not located in a "fire storm" area. That is, an area where many fires have broken out simultaneously throughout an extensive region of closely spaced combustible buildings. Such an area would very likely be uninhabitable because of oxygen deficiency and toxic gases.
4. There will be no fire fighting by public fire departments.
5. Public water supplies and electric utilities will be in service.
6. Automatic sprinkler systems, as available, will be in service.
7. Occupants of shelter areas will make periodic fire inspection tours of the shelter building; and in addition, responsible personnel will be familiar with fire-fighting equipment, including operation of automatically and manually controlled sprinkler systems.

GLOSSARY

<u>Combustible</u>	Any material which will ignite and burn. Examples are metals such as sodium and magnesium, organic materials such as wood, paper, rubber, textiles, gasoline, oil, acetylene, hydrogen, etc. When referring to roof and floor construction of buildings, three (3) classes of the National Building Code are considered combustible, i.e., heavy timber construction, ordinary construction, and wood-frame construction.
<u>Noncombustible</u>	Any material which will not ignite and burn except under unusual conditions such as being in an atmosphere of pure oxygen, e.g., brick, stone, concrete, steel, etc. When referring to roof and floor construction of buildings, four (4) classes of the National Building Code are considered noncombustible, i.e., Type A and Type B fire-resistive construction, and protected and unprotected noncombustible construction.
<u>Fire Loading</u>	Kind and amount of combustibles.
<u>HIGH FIRE LOAD OCCUPANCIES</u>	Concentrations of combustible storage such as lumber, millwork, furniture, textile, paper, or rubber products, and crated appliances, particularly if storage is in high piles or tiered racks. Congested mercantile occupancies, processing of flammable liquids or hazardous chemicals. Machine shops using cutting oils, printing, cloth or leather working, multiunit dwellings, commercial and service garages, and most retail stores.
<u>LOW FIRE LOAD OCCUPANCIES</u>	Metalworking (without flammable liquids), hospitals, offices, auditoriums, schools, theaters, and modern hotels.
<u>Enclosed Stairways or Elevators</u>	Any complete partition around the floor openings from floor to ceiling. May be constructed of any material.
<u>Masonry</u>	A broad term for any wall construction using brick, concrete, stone, concrete or cinder block, etc.
<u>Smooth Surface Roof Covering</u>	Any roofing which is combustible. Includes wood shingles, plain asphalt shingles, and all built-up roofings which do not have gravel or slag surface coverings.
<u>Ordinary Hazard Occupancies</u>	Offices, hospitals, schools, theaters, hotels, auditoriums, multiunit dwellings and most retail stores. Metalworking, machine shops, printing, cloth or leather working, commercial and service garages are also in this category.

Extra Hazard
Occupancies

Processing of flammable liquids or hazardous chemicals, congested mercantile occupancies. Concentrations of storage such as lumber, furniture, millwork, textile, paper or rubber products, and crated appliances, particularly if storage is in high piles or tiered racks.

Complete Automatic
Sprinkler Protection

Where the term "Complete Automatic Sprinkler Protection" appears in blocks for the block diagrams on Sheets 2 and 4, it means that sufficient sprinklers are provided where needed for combustible construction or occupancy. It does not mean that sprinklers must be present throughout a building where the need does not exist.

INSTRUCTIONS FOR USE OF BLOCK DIAGRAMS

The analysis of the fire hazard of the building housing the shelter area, designated as Zone 2, is accomplished through the use of block diagrams analogous to a flow chart. It is suggested that the analyst look carefully at these diagrams before beginning his survey.

These are three sheets of diagrams covering: (1) occupancy features and protection for the occupancy; (2) the building construction features and their protection and; (3) a special diagram for basement or sub-basement shelter areas where it has been ascertained that the building occupancy is noncombustible.

In using any one of the block diagrams, the analyst starts at the top of the form to determine the initial condition. To the right is safe, to the left unsafe. For example, the "Occupancy (Use) and Protection Analysis" diagram, Sheet 2 provides a choice of two conditions - the building is either "occupied" (in use) or it is "vacant". If the building is vacant, the analyst reaches a "dead end" immediately in the section designated at the bottom as "Class A" and this portion of the Survey is completed. If, however, the building is occupied, the "Occupied Building" block is marked and the arrowed routes are followed to a choice of either of two types of occupancy, i.e. "Extra Hazard Occupancy" or "Ordinary Hazard Occupancy". Note that paths must be followed in the direction of the arrows only.

Using judgment along with readily determined physical features, the analyst will mark the route he has followed through the maze, ending at a block on the diagram which has no outlet path. This block will fall in a section or column identified at the bottom by a Class letter - A, B, C or D, Class A being the best shelter rating.

The class marked on the block diagram is entered on Page 15, "Summary - Deficiencies and Ratings". All deficiencies - factors which result in a rating lower than Class A - are entered on this summary sheet.

The special block diagram which pertains only to basement and subbasement shelters analyzes construction only after it has been determined from the occupancy and protection analysis that automatic sprinkler protection is not needed, i.e. occupancy is noncombustible. In this case only, Zone 3 - Exposure need not be analyzed except for flammable liquid exposures. If the basement or subbasement shelter has a combustible occupancy or construction, it is analyzed as any other shelter area and exposure conditions must be determined.

In order to avoid confusion in the block diagram, occupancy conditions and construction features are treated on separate sheets. However, it is expected that the person making the survey will start in the top story and descend observing all necessary survey factors while in each story. A separate Floor Sheet (See Page 5a) should be used for recording complete data for each floor. In other words, a separate inspection tour should not be made to first check the occupancy and, second, to check the construction. Before starting the survey of Zone 2, the story Nos. containing shelter area(s) (Zone 1) should be established by inquiry and noted; in order to establish the boundaries of Zone 2.

FLOOR SHEET FOR EASY RECORDING OF SURVEY DATA IN ZONE 2

Complete this sheet before leaving this floor, and
use it later in Block Diagrams (Sheets 2, 3 & 4).

Bldg. Name _____

Date Survey _____

OCCUPANCYVACANT ☐ Remarks _____EXTRA HAZARD OCCUPANCY ☐ Rmks _____ORDINARY HAZARD OCCUPANCY ☐ Rmks _____

Noncombustible Products, Process, Packaging, or Storage ☐ Rmks _____
 Metal Desks, Files, etc. or Limited Office Furniture ☐ Rmks _____
 Wood Desks, Files, Office Supplies Not in Metal Cabinets ☐ Rmks _____
 Combustible Products, Process, Pkg, or Stge. ☐ Rmks _____

CONSTRUCTIONROOF DECK: Combustible ☐ Noncombustible ☐ Rmks _____

ROOF COVERING: Smooth Surface Combustible ☐ Gravel, Slag, Slate or Tile ☐
 Rmks _____

FLOOR: Combustible ☐ Noncombustible ☐ Rmks _____

INTERIOR PARTITIONS & CEILINGS: Combustible ☐ Noncombustible ☐ None ☐
 Rmks _____

STAIRWAYS & ELEVATORS: Enclosed ☐ Not Enclosed ☐ Rmks _____

WINDOWS: Wired-glass Metal Sash or Glass Block ☐ Fire Shutters ☐
 Other ☐ No Windows ☐ Rmks _____

AIR TO SHELTER (Zone 1): Depends on Supply to Above-grade Stories ☐
 Independent ☐ Rmks _____

FLAMMABLE LIQUID EXPOSURE (See G-5): Unacceptable ☐ Acceptable ☐PROTECTIONAUTOMATIC SPRINKLERS: Complete ☐ None ☐ Rmks _____

WATER SUPPLY FOR AUTOMATIC SPRINKLERS : Public Water Only ☐
 Water Supply Available if P.W. Fails ☐ Rmks _____

ZONE 3 - EXPOSURE ANALYSIS

I Zone 3 is considered to be all exposing property within 400 ft. of Zone 2 which presents a possible fire hazard to the shelter building. If exposures consist of flammable liquid or liquefied petroleum gas storage in excess of 250,000 gallons, the limiting distance for Zone 3 will be dependent on safe limiting distances shown on page G-5.

II Factors Used for Evaluation

A. Severity of exposure is based on factors affecting the intensity of a fire in the exposing property, and the ability of the exposed shelter-housing (Zone 2) to withstand the expected fire intensity.

B. Factors considered for exposures from buildings:

1. Fire Loading* which is graded as High* or Low*. If exposing building is sprinklered, consider high fire loading as "Low".
2. Type of exposure building.
 - a. Combustible* - either floors and/or roof or walls.
 - b. Entirely noncombustible*
3. Wall length of exposing building.
4. Height of exposing building. (For this study, each story is considered to be 15 ft. high.)

C. Factors considered for exposures other than from buildings:

1. Lumber storage, (See Note 3, Page G-2 and Note 2, Page G-2A.)
2. Flammable liquids, liquefied petroleum gases and gas holders. (See Page G-5.)

D. Factors considered for protecting Zone 2:

1. Separation (space) between exposing property and shelter-housing (Zone 2) alone.
2. Wired glass in steel sash windows for exposed building. (Glass block panels may be considered equivalent.)
3. Fire shutters or fire doors for openings in walls of Zone 2. An alternate to these protected openings is blank masonry* walls for Zone 2 or a blank masonry wall for the exposing building if the exposing building is as high or higher than Zone 2.
4. If exposure building has both noncombustible construction and occupancy, none of the above protection factors for Zone 2 are needed.

* See Glossary

ZONE 3 - PROCEDURE FOR CLASSIFYING EXPOSING PROPERTY

NOTE: Exposure must be evaluated for all directions.

I Approach

A. Basic considerations

1. All buildings presenting a vertical face which can produce a heat radiating surface within 400 ft. of Zone 2 must be evaluated for severity of their exposures to Zone 2. (See Exhibits A, B, C, and D.)
2. Flammable liquid storages or liquefied petroleum gases must be evaluated for exposure to a distance from Zone 2 which will be dependent on the amount of storage. (See Page G-5). It should be noted that if ground slope is such that flammable liquids can run down to the shelter building, the shelter is rated "Class D".

B. Explanation of alignment diagrams

1. Alignment diagrams for determining severity of all exposures are identified by the letter "G" followed by a number. If the number is followed by the suffix "A", it means the wall of Zone 2 has wired glass in steel sash windows (or glass block panels). Without the "A" suffix, the alignment diagram is based on the wall of Zone 2 having plain glass windows or wood sash.
2. The first four alignment diagrams, Pages G-1 through G-2A, are based on combustible exposing buildings with Pages G-2 and G-2A also specifically including lumber storage.

The next four pages, G-3 through G-4A, are based on noncombustible exposing buildings.

The last page, G-5, pertains exclusively to flammable liquid type exposures.

3. Alignment diagrams for a particular exposing building construction are arranged in an ascending order of fire loading.

C. Suggested order of steps in analysis.

1. Consult Sanborn Maps available at insurance and some public libraries for area in which shelter is located. These maps will provide information on occupancy, construction and number of stories of exposing buildings as well as separation distances between buildings.

Where these maps are not available, valuable information is often available from city officials; such as, tax appraisers, assessors, and city engineers. If information from none of these sources is available, a personal tour of the area will probably be necessary.

2. Determine protection factors present for all walls of Zone 2 (See Page 6, II, D) while making survey of Zone 2.
3. Determine from alignment diagrams (Pages G-1 through G-5) classification of shelter.

II Use of alignment diagrams (Pages G-1 through G-5)

A. Using information obtained in "C-1" above,

1. Determine whether fire load of exposure is high or low. (See "Glossary" for definitions).
2. Determine exposing building construction.
3. Determine number of stories of exposing building. (Diagrams may be interpolated).
4. Determine distance of exposing property from Zone 2.
5. Determine wall-length of exposing building, lumber-pile(s), face-length, or number of gallons of flammable liquid (Page G-5),
6. Steps 1 through 5 above will determine shelter classification, Class A or Class D, in conjunction with protection factors described under "D. Factors Considered for Protecting Zone 2:". Page 6.

Example: Building exposure to one side of Zone 2 has following characteristics:

- (1) It is a rubber tire warehouse without automatic sprinklers. (High Fire Load)
- (2) Construction consists of brick walls and plank roof. (Combustible)
- (3) Warehouse is one story (15 ft.) high.
- (4) Warehouse wall facing Zone 2 is 300 ft. long.

Protection factors for Zone 2 consist of:

- (1) Separation distance of 50 ft., i.e. distance of exposing Warehouse from Zone 2 is 50 ft.

Since construction of the exposing building is combustible, occupancy is a high fire loading, and there are no protection factors other than separation distance, the alignment diagram on Page G-2 is used.

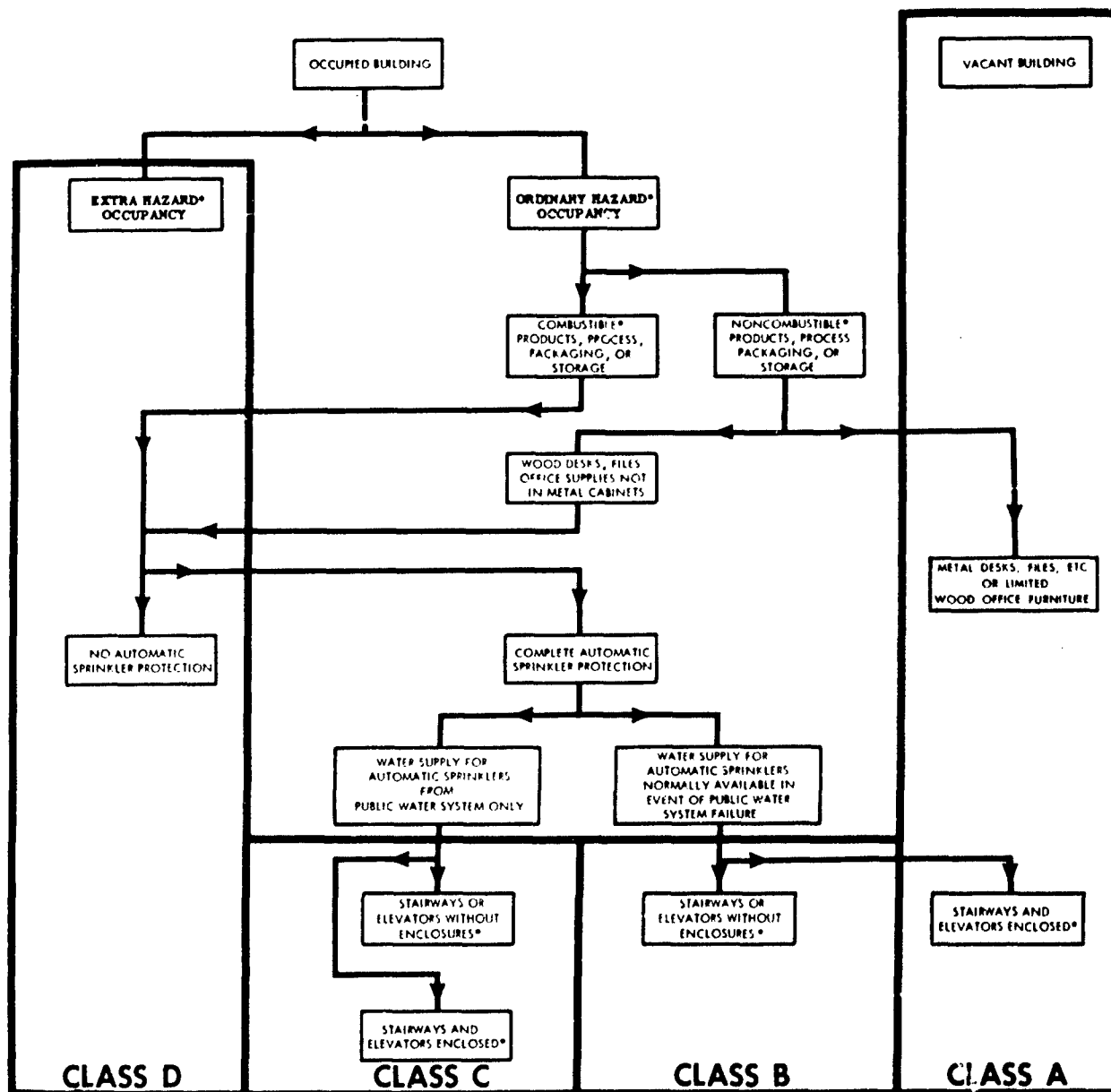
Using a straight edge and aligning the 300-foot wall length with the dividing line between Class A and Class D, it is found that the required separation distance is 100 ft. Therefore, the shelter is rated as Class D. If, however, the wall of Zone 2 were to have

wired-glass in steel sash windows, Page G-2A is used and shows a separation distance of 45 ft. is satisfactory and the shelter rating would be Class A. NOTE: Also see Exhibits A, B, C and D.

SHEET 2

OCCUPANCY (USE) AND PROTECTION ANALYSIS (ZONE 2)

Note: Mark each applicable block to show route followed.



Check Class indicated in column where your marked route ended.

Class A ☐ Class B ☐ Class C ☐ Class D ☐

If this is a basement or subbasement shelter and rates CLASS A without automatic sprinkler protection, continue on Sheet 3.

If such is not the case, go directly to Sheet 4.

Enter all deficiencies on page 16.

Enter Class checked above on page 17, SUMMARY - DEFICIENCIES AND RATINGS.

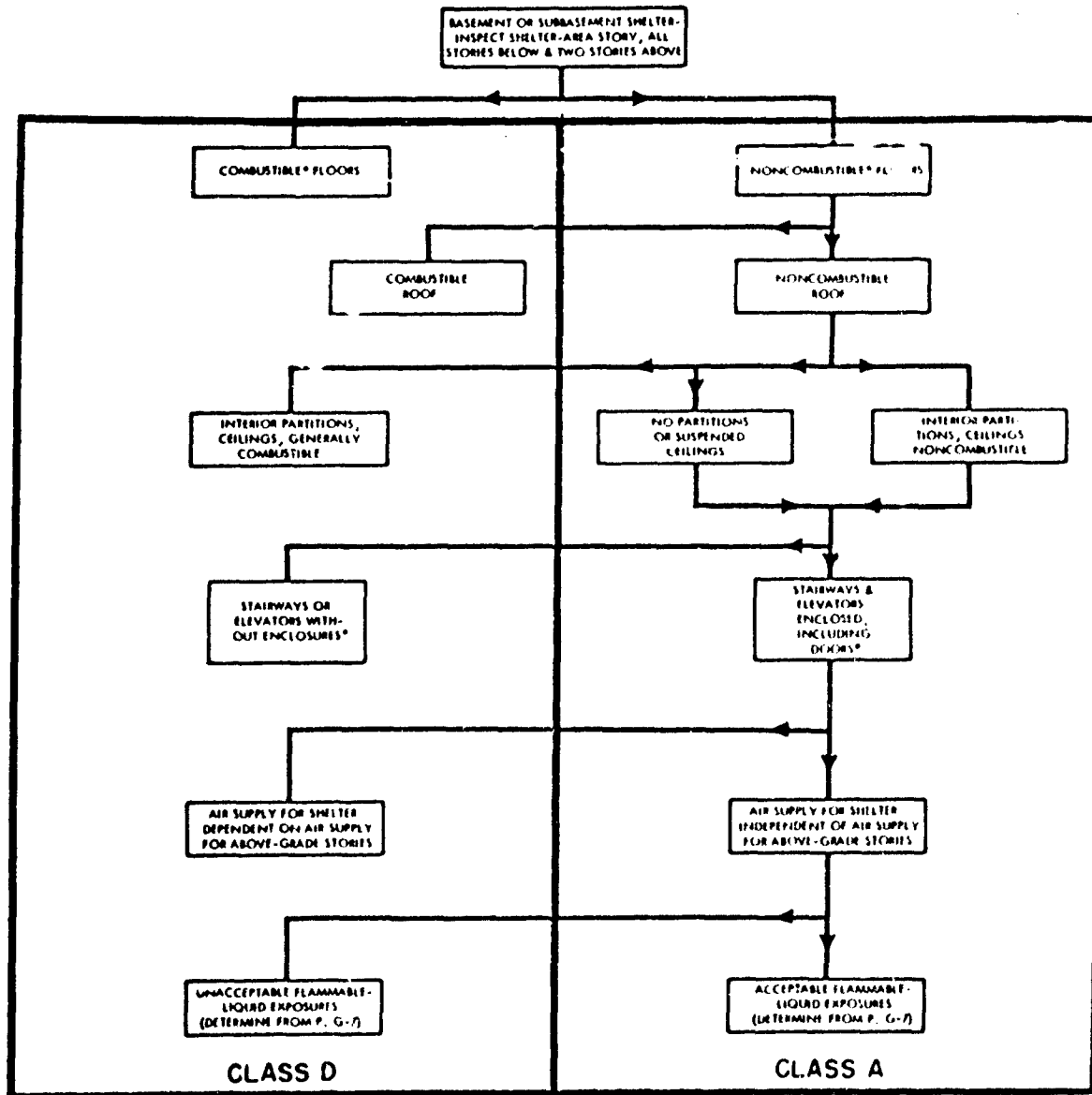
*SEE GLOSSARY

SHEET 3

Use only if Sheet 2 specifies.

CONSTRUCTION AND PROTECTION ANALYSIS (ZONE 2)
FOR BASEMENT OR SUBBASEMENT SHELTER

Note: Mark each applicable block to show route followed.



Check Class indicated in column where your marked route ended.

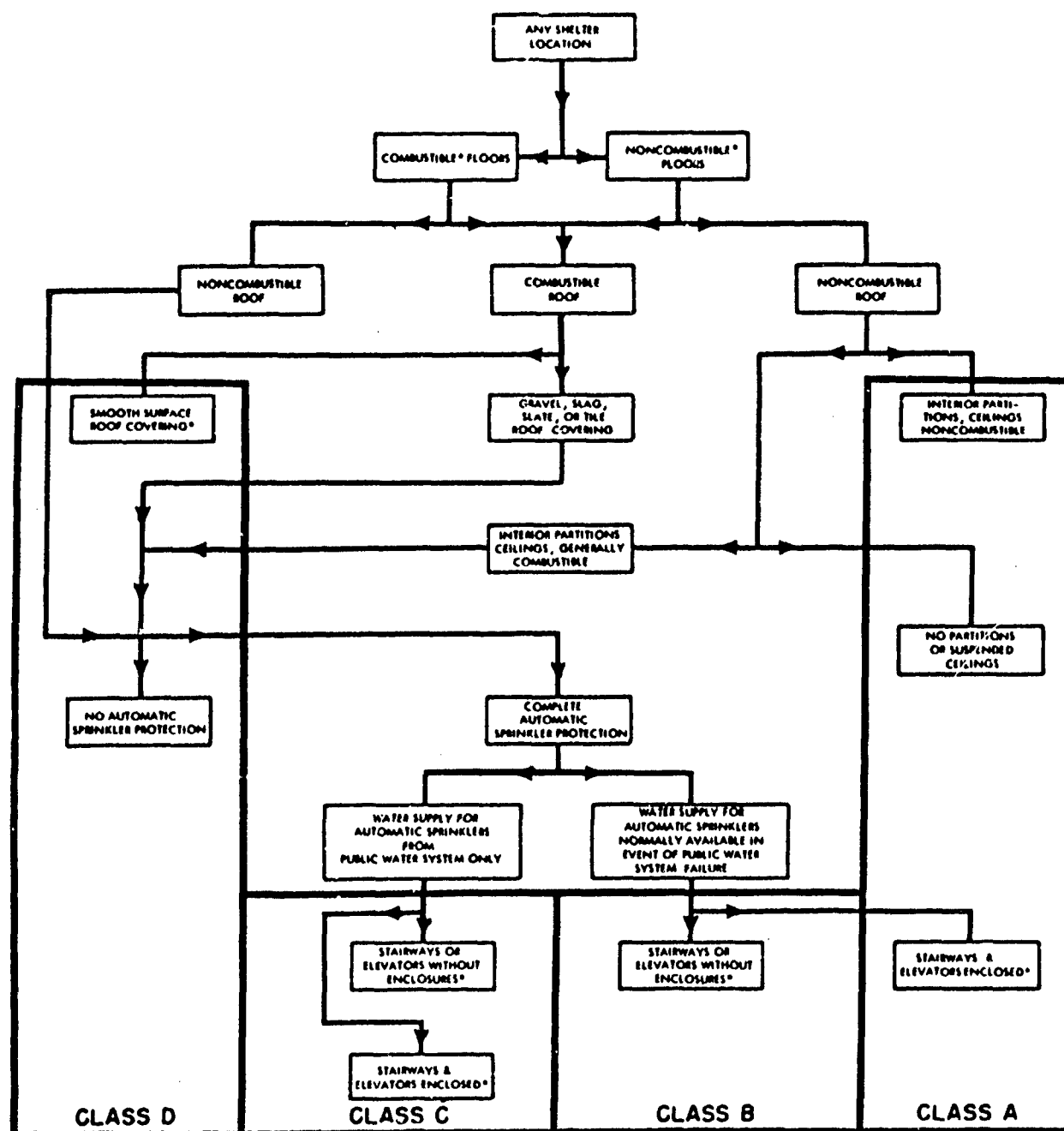
Class A ☐ Go to page 17 and check FINAL CLASSIFICATIONClass D ☐ Continue on Sheet 4

*SEE GLOSSARY

SHEET 4

CONSTRUCTION AND PROTECTION ANALYSIS (ZONE 2)

Note: Mark each applicable block to show route followed.



Check Class indicated in column where your marked route ended.

Class A ☐ Class B ☐ Class C ☐ Class D ☐

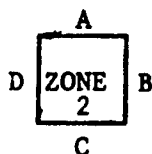
Enter all deficiencies on page 16.

Enter Class checked above on page 17, SUMMARY - DEFICIENCIES AND RATINGS. Continue on page 15.

*SEE GLOSSARY

ZONE 3 RATING SHEET

Note: See sketch for rating each side of Zone 2.



Does Zone 3 have a Class A rating without modifications?

Side A	Yes <input type="checkbox"/>	No <input type="checkbox"/>
Side B	Yes <input type="checkbox"/>	No <input type="checkbox"/>
Side C	Yes <input type="checkbox"/>	No <input type="checkbox"/>
Side D	Yes <input type="checkbox"/>	No <input type="checkbox"/>

The following improvements are needed:

	No feasible Improvement- Flammable Liquid Exposure and Unfavorable Ground Slope	Wired-glass in Steel Sash Windows	Fire Shutters, Fire Doors or Blank Masonry Wall
Side A	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Side B	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Side C	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Side D	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

ZONE 3 RATING

If all sides of Zone 2 are rated CLASS A without modifications, check CLASS A.

If any side is rated CLASS D, check CLASS D.

CLASS A ☐

CLASS D ☐

Transfer ZONE 3 RATING to page 15, SUMMARY - DEFICIENCIES AND RATINGS.

SUMMARY - DEFICIENCIES AND RATINGS

DEFICIENCIES - Transfer from Analysis Sheets

I Zone 2 - Occupancy - Sheet 2 - Check all applicableExtra Hazard Occupancy ☐Stairways or Elevators without Enclosures ☐Water Supply for Automatic Sprinklers from Public Water System Only ☐No Automatic Sprinkler Protection ☐II Zone 2 - Construction - Sheet 4 - Check all applicableSmooth Surface Roof Covering ☐Stairways or Elevators without Enclosures ☐Water Supply for Automatic Sprinklers from Public Water System Only ☐No Automatic Sprinkler Protection ☐III Zone 3 - Exposure - Page 13 - Check all applicable

Wired Glass in Steel Sash needed in Zone 2 for:

Side A ☐Side B ☐Side C ☐Side D ☐

Fire shutters, fire doors or blank masonry walls needed in Zone 2 for:

Side A ☐Side B ☐Side C ☐Side D ☐

Flammable liquid exposure with ground sloping down to Zone 2 at:

Side A ☐Side B ☐Side C ☐Side D ☐

FINAL RATINGS - Transfer from Analysis Sheets

I Zone 2 - Occupancy and Protection

(From page 10)

Class A ☐Class B ☐Class C ☐Class D ☐

II Zone 2 - Construction and Protection

(From page 12)

Class A ☐Class B ☐Class C ☐Class D ☐

III Zone 3 - Exposure

(From page 13)

Class A ☐
(All sides)Class D ☐
(Any side)

FINAL CLASSIFICATION OF SHELTER

Note: Use lowest class checked under FINAL RATINGS groups.
Class D is the lowest possible class.

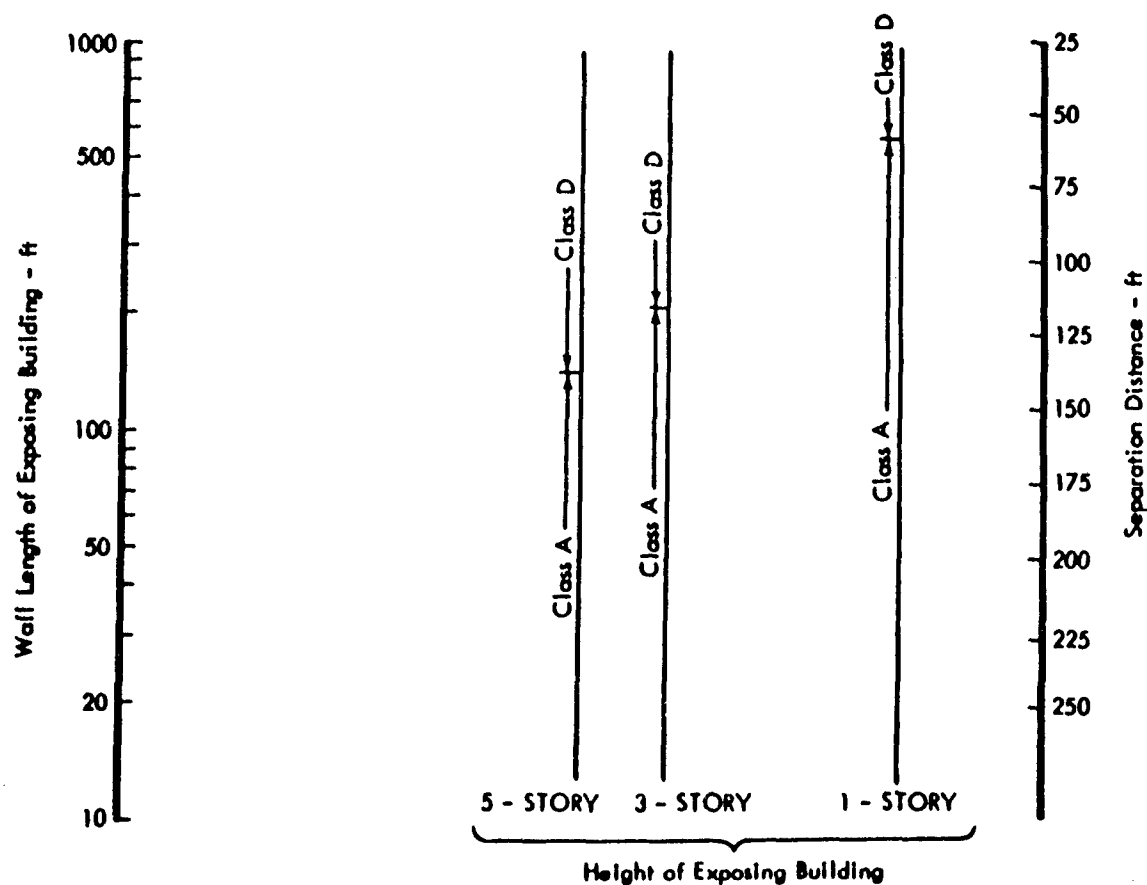
Include Basement and Subbasement Shelters from Sheet 3 if
Class A.

CLASS A ☐CLASS B ☐CLASS C ☐CLASS D ☐

ALIGNMENT DIAGRAM

LOW FIRE- LOAD OCCUPANCY AND COMBUSTIBLE FLOORS OR
ROOF IN EXPOSING BUILDING (ZONE 3)

PLAIN GLASS WINDOWS OR WOOD SASH IN EXPOSED BUILDING (ZONE 2)

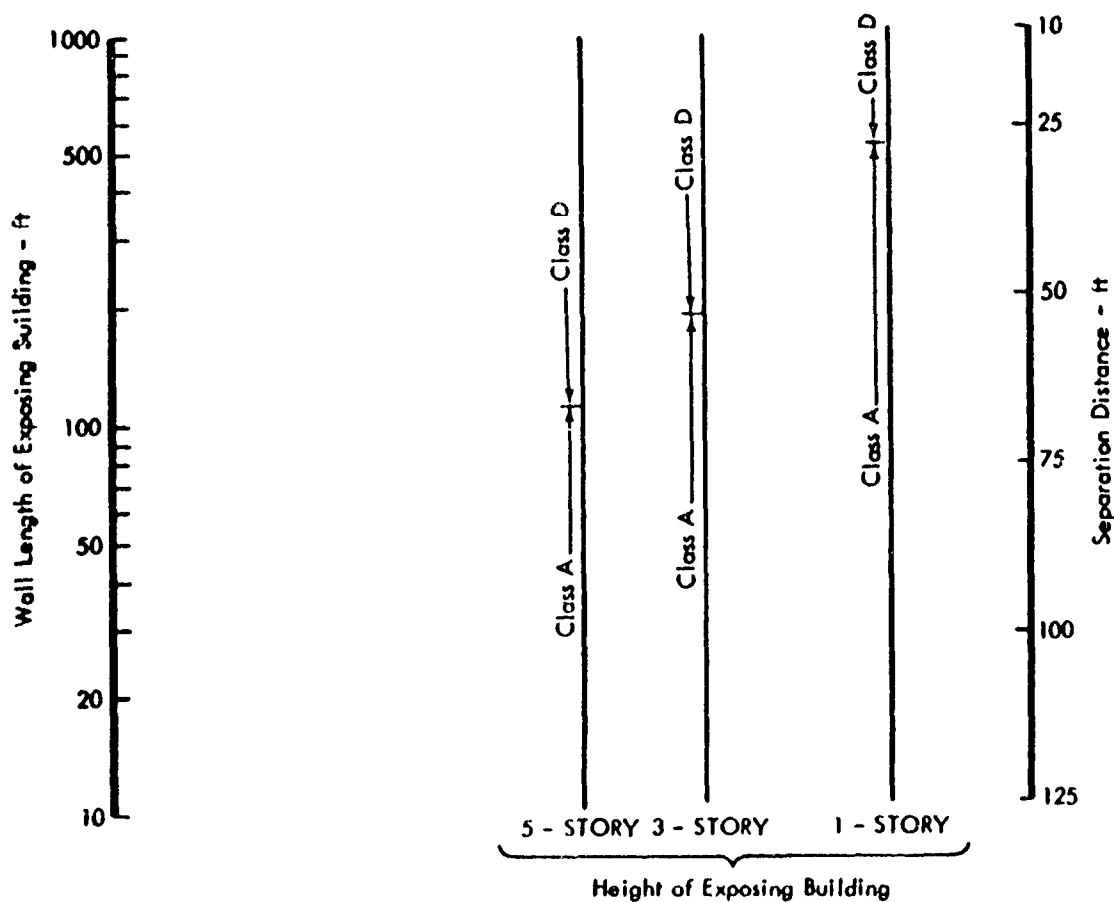


- NOTES: (1) If exposed building (Shelter) has wired glass in steel sash windows, use Alignment Diagram on page G-1A.
- (2) If rating is Class D, use page G-1A to determine if wired glass windows in steel sash will result in a Class A Rating.

ALIGNMENT DIAGRAM

LOW FIRE-LOAD OCCUPANCY AND COMBUSTIBLE FLOORS OR
ROOF IN EXPOSING BUILDING (ZONE 3)

WIRED GLASS WINDOWS IN STEEL SASH IN EXPOSED BUILDING (ZONE 2)

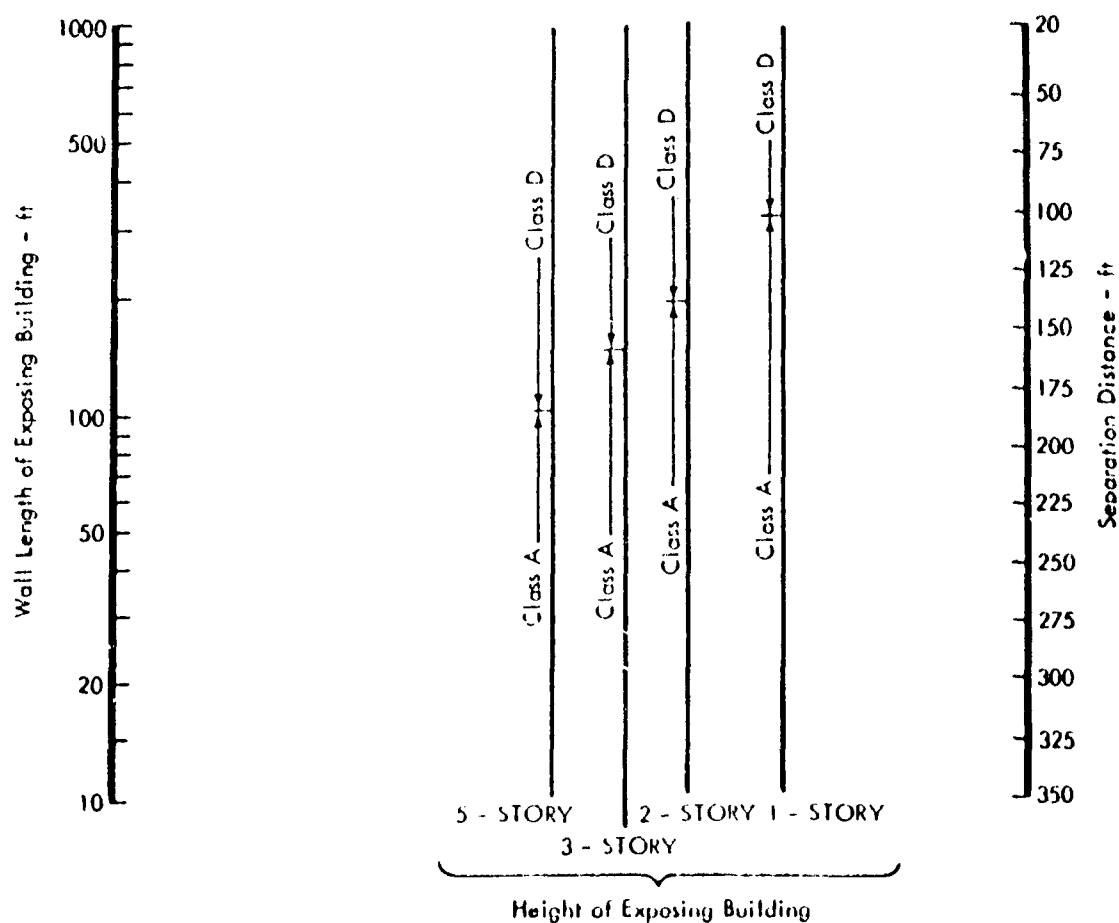


NOTE: If Separation Distance is less than required for Class A Rating, fire shutters and/or doors are needed for all wall openings, or blank masonry is required

ALIGNMENT DIAGRAM

HIGH FIRE-LOAD OCCUPANCY AND COMBUSTIBLE FLOORS OR
ROOF IN EXPOSING BUILDING (ZONE 3)

PLAIN GLASS WINDOWS OR WOOD SASH IN EXPOSED BUILDING (ZONE 2)

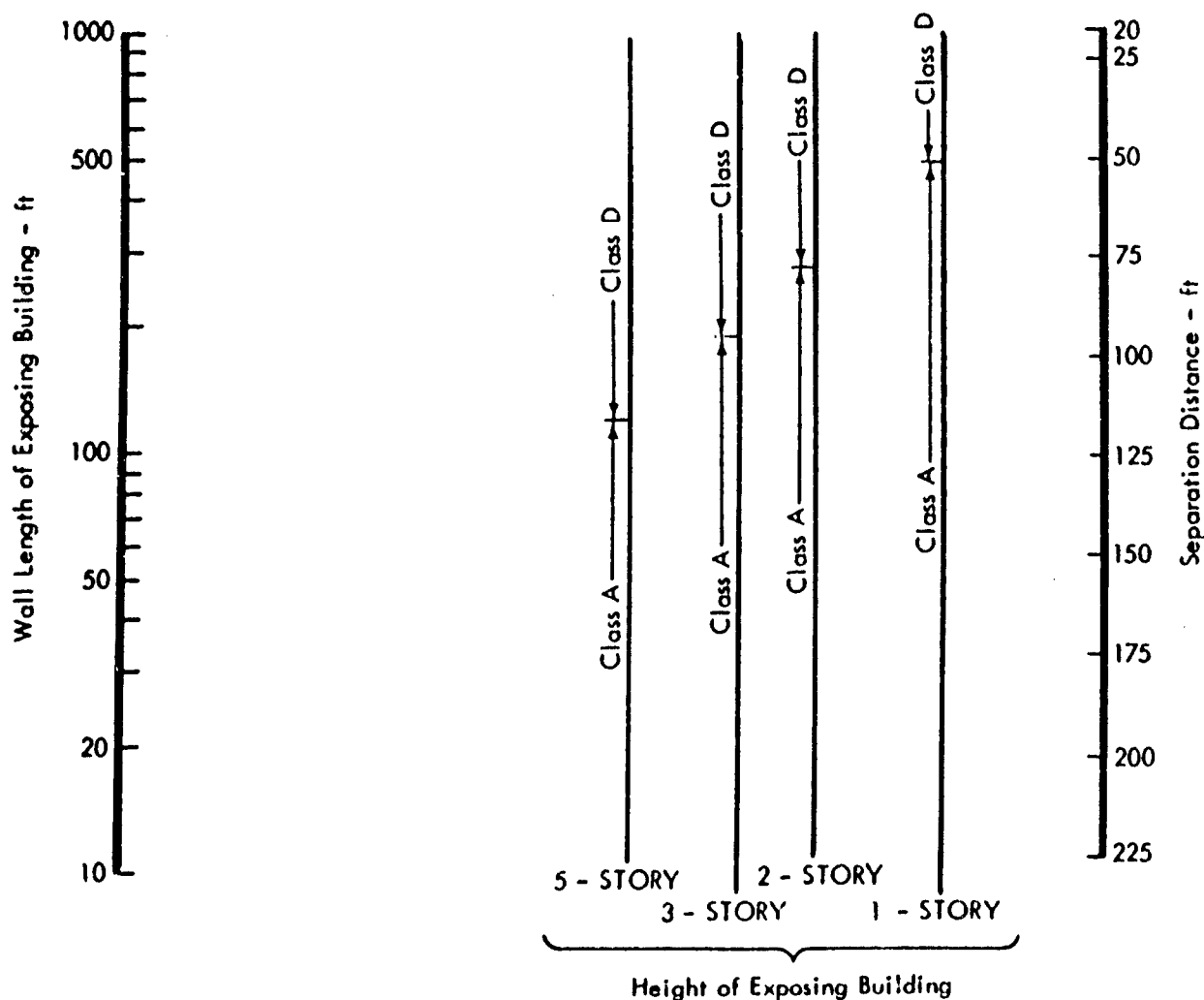


- NOTES: (1) If exposed building (Shelter) has wired glass in steel sash windows, use Alignment Diagram on page G-2A.
- (2) If Rating is Class D, use page G-2A to determine if wired glass windows in steel sash will result in a Class A Rating.
- (3) Lumber Storage - Figure length of pile(s), and use as wall length of exposing 5-story building.

ALIGNMENT DIAGRAM

HIGH FIRE-LOAD OCCUPANCY AND COMBUSTIBLE FLOORS OR
ROOF IN EXPOSING BUILDING (ZONE 3)

WIRED GLASS WINDOWS IN STEEL SASH IN EXPOSED BUILDING (ZONE 2)

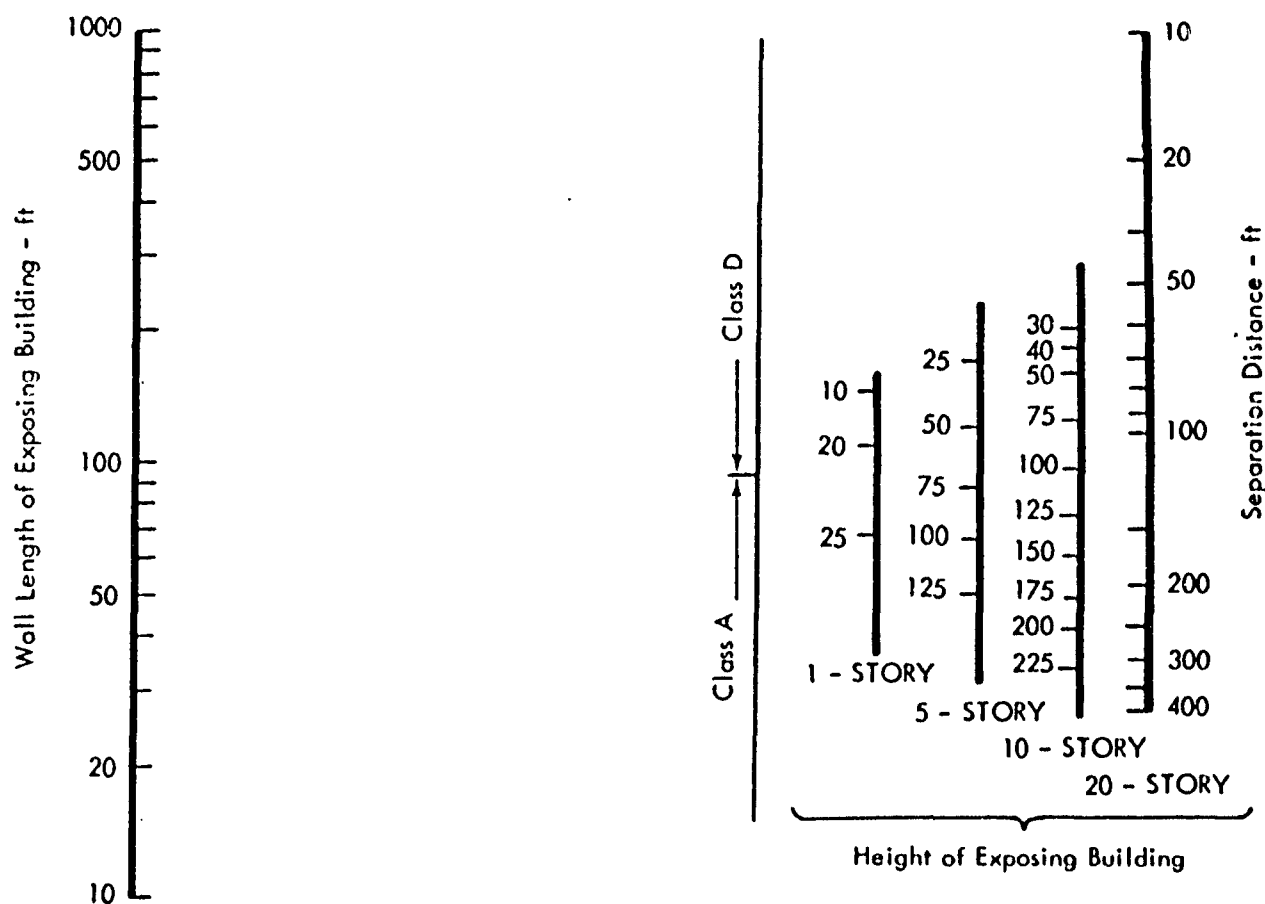


- NOTES: (1) If Separation Distance is less than required for a Class A Rating, fire shutters and/or doors are needed for all wall openings, or blank masonry is required.
- (2) Lumber Storage - Figure length of pile(s), and use as wall length of exposing 5-story building.

ALIGNMENT DIAGRAM

LOW FIRE-LOAD OCCUPANCY AND NONCOMBUSTIBLE FLOORS
AND ROOF IN EXPOSING BUILDING (ZONE 3)

PLAIN GLASS WINDOWS OR WOOD SASH IN EXPOSED BUILDING (ZONE 2)

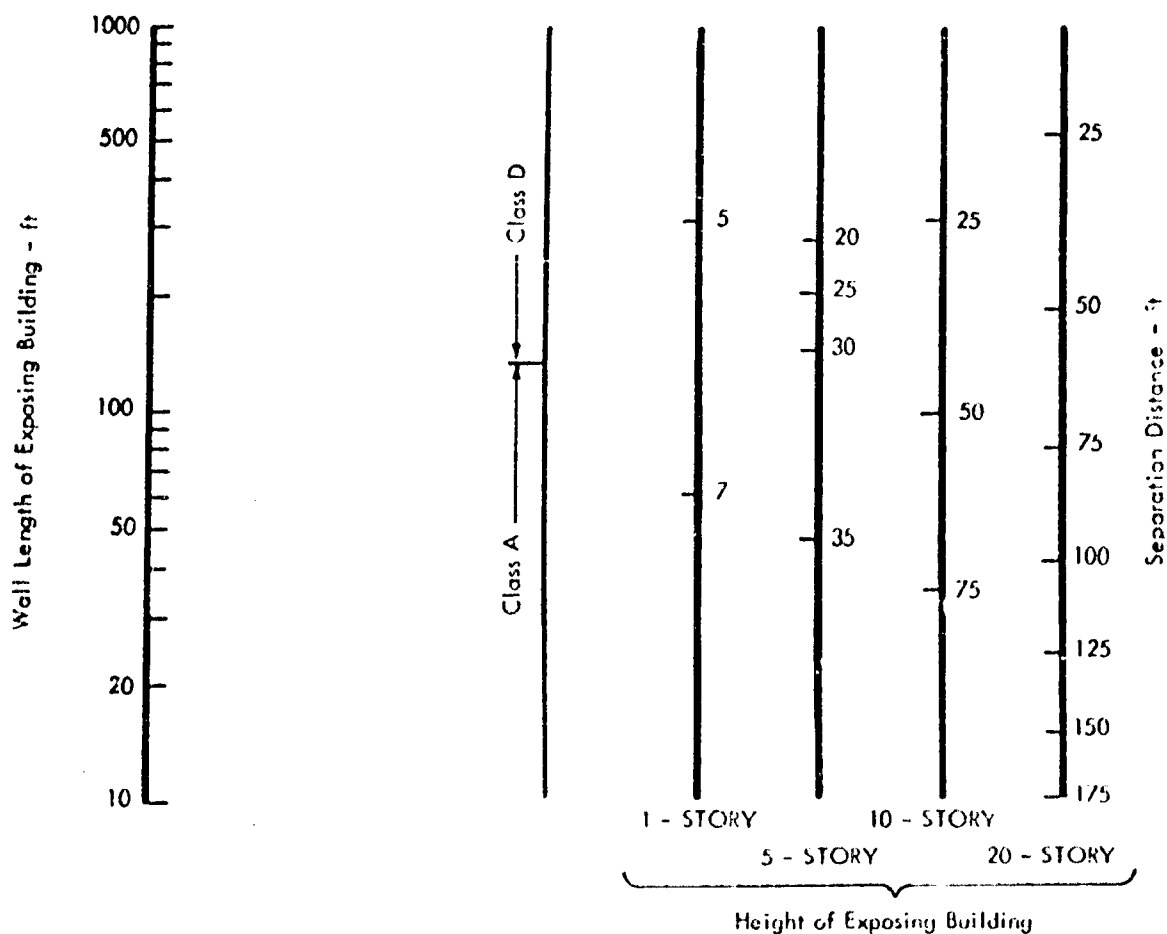


- NOTES: (1) If exposed building (Shelter) has wired glass in steel sash windows, use Alignment Diagram on page G-3A.
- (2) If Rating is Class D, use page G-3A to determine if wired glass windows in steel sash will result in a Class A Rating.

ALIGNMENT DIAGRAM

LOW FIRE-LOAD OCCUPANCY AND NONCOMBUSTIBLE FLOORS AND ROOF
IN EXPOSING BUILDING (ZONE 3)

WIRED GLASS WINDOWS IN STEEL SASH IN EXPOSED BUILDING (ZONE 2)

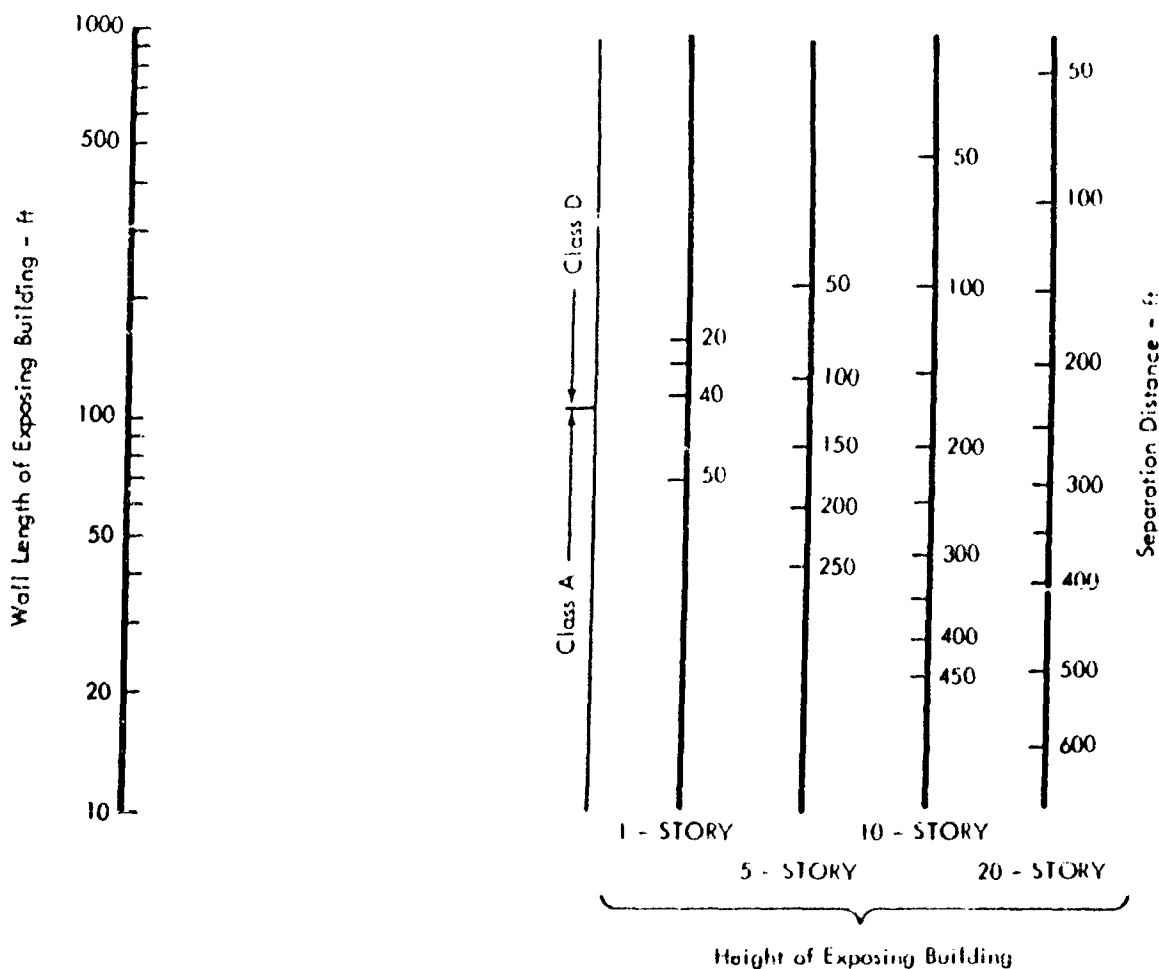


NOTE: If Separation Distance is less than required for a Class A Rating, fire shutters and/or doors are needed for all wall openings, or blank masonry is required.

ALIGNMENT DIAGRAM

HIGH FIRE-LOAD OCCUPANCY AND NONCOMBUSTIBLE FLOORS
AND ROOF IN EXPOSING BUILDING (ZONE 3)

PLAIN GLASS WINDOWS OR WOOD SASH IN EXPOSED BUILDING (ZONE 2)

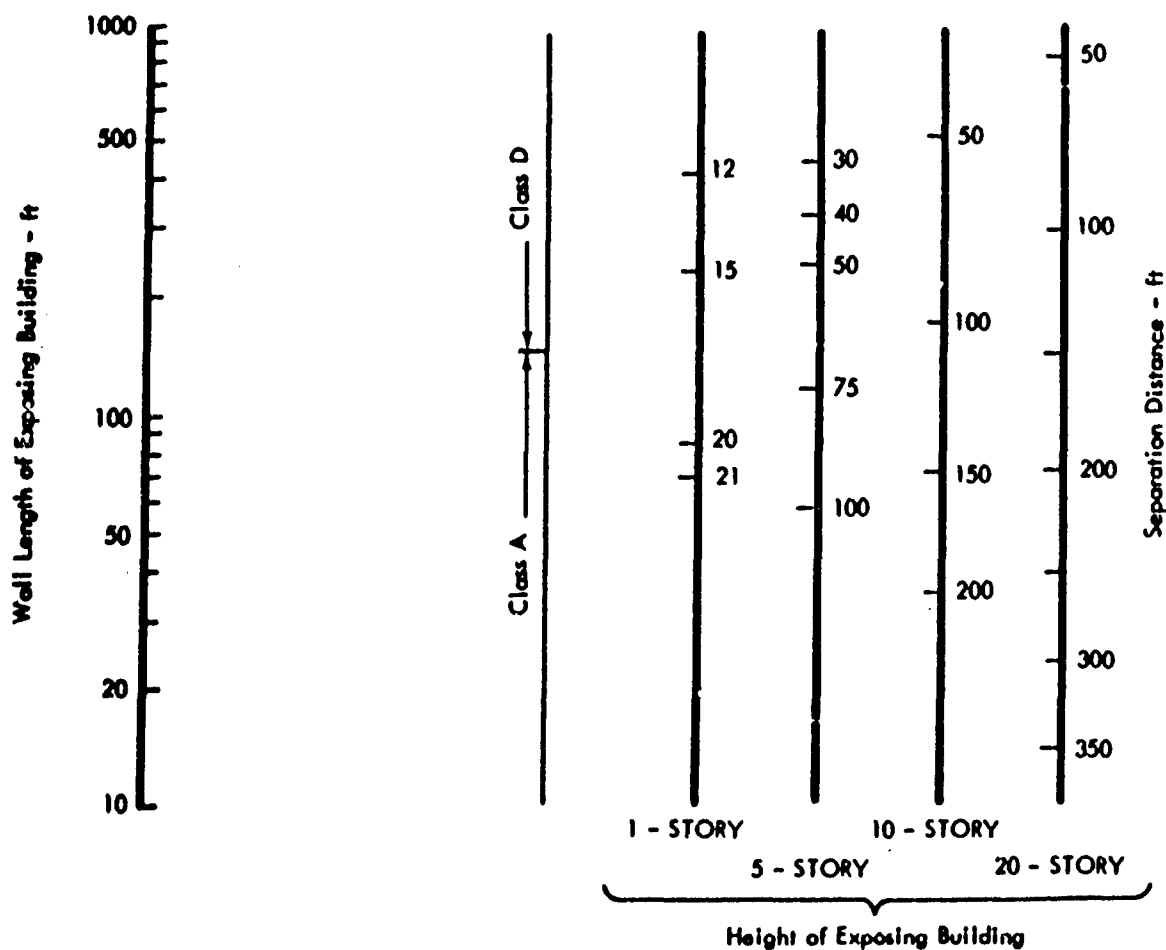


- NOTES: (1) If exposed building (Shelter) has wired glass in steel sash windows, use Alignment Diagram on page G-4A.
- (2) If Rating is Class D, use page G-4A to determine if wired glass windows in steel sash will result in a Class A Rating.

ALIGNMENT DIAGRAM

HIGH FIRE-LOAD OCCUPANCY AND NONCOMBUSTIBLE FLOORS
AND ROOF IN EXPOSING BUILDING (ZONE 3)

WIRED GLASS WINDOWS IN STEEL SASH IN EXPOSED BUILDING (ZONE 2)

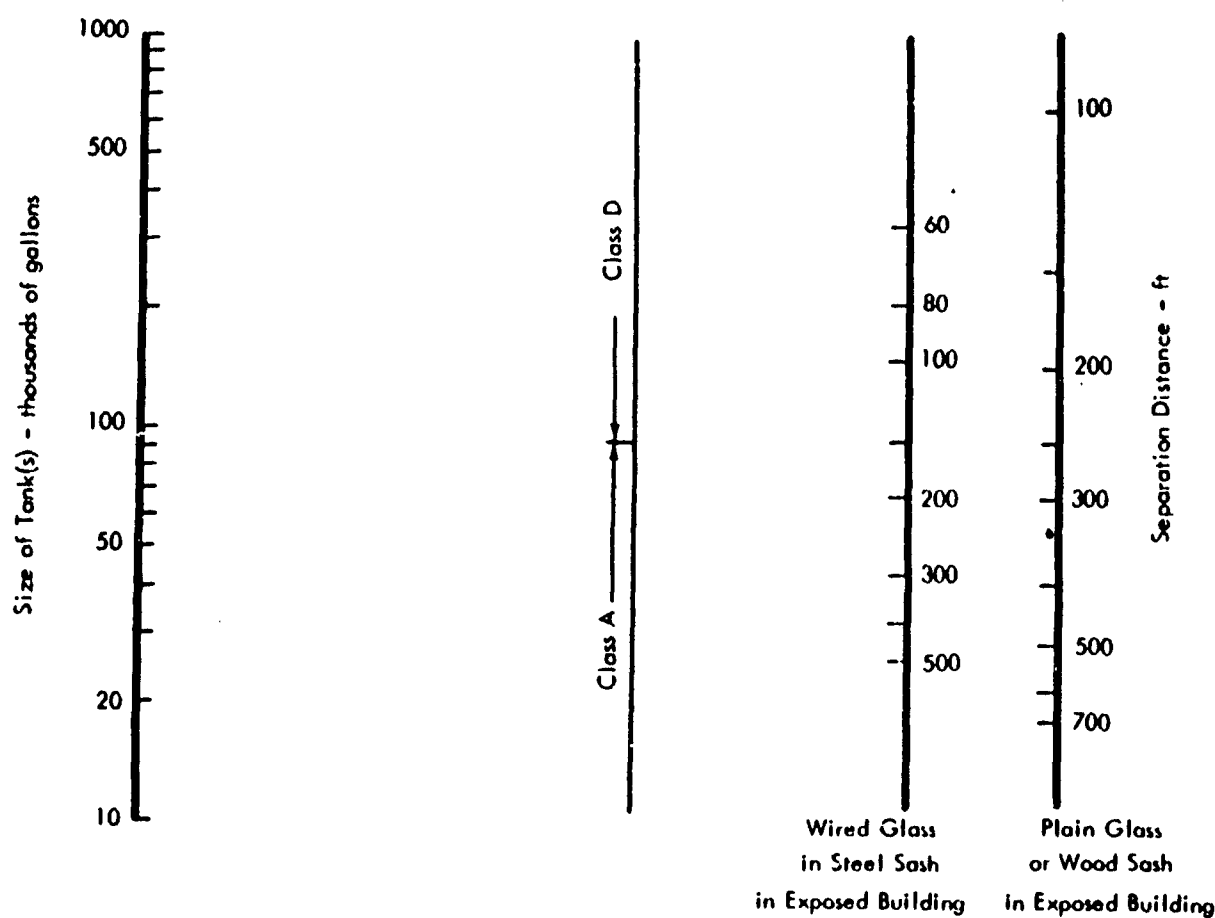


NOTE: If Separation Distance is less than required for a Class A Rating, fire shutters and/or doors are needed for all wall openings, or blank masonry is required.

ALIGNMENT DIAGRAM

LIQUIFIED PETROLEUM GAS OR FLAMMABLE LIQUID STORAGE
TANK EXPOSURES (ZONE 3)

GROUND SLOPING AWAY FROM EXPOSED BUILDING (ZONE 2)



- NOTES: (1) Gas Holders require Separation Distance of 25 ft. If less, provide wired glass in steel sash windows for exposed building.
- (2) If ground slopes toward Shelter Building, Shelter is Class D.



NOTE: Blank Masonry Walls indicated by heavy lines —

ZONE 3 - EXPOSURE ANALYSIS:

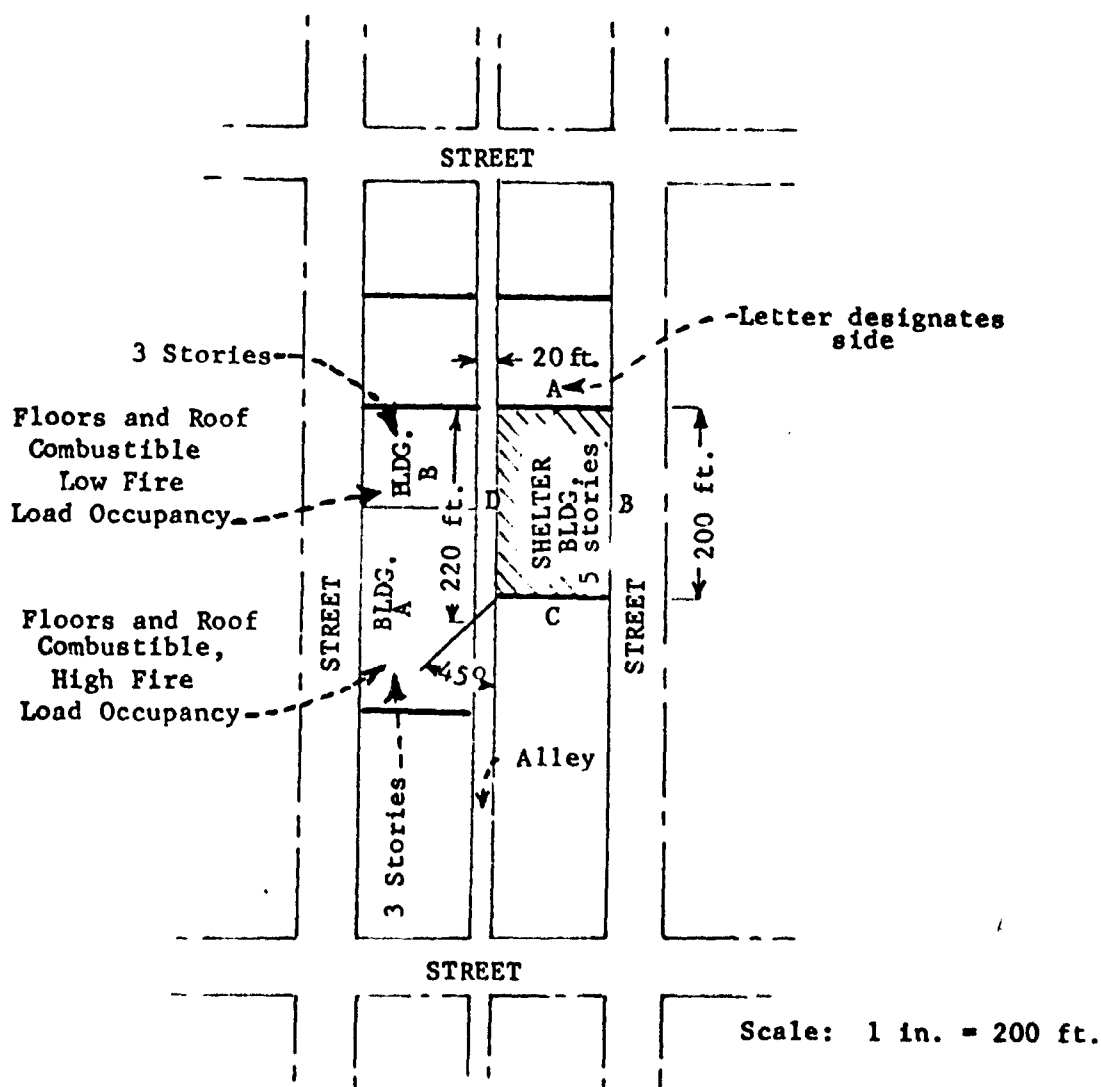
Exposure to be considered to Side D consists only of Building "B" with the alignment of blank masonry walls shown.

Although a Furniture Warehouse would be a High Fire Load Occupancy (See Glossary), the fact that Building "B" is sprinklered reduces the fire loading to "Low."

The wall length of Building "B" is 200 feet and the Separation Distance is 20 feet.

The Alignment Diagram on Page G-3 is used for a 3-story building which shows that a Separation Distance of 60 feet is needed. Thus the 20-foot distance results in a "Class D" shelter rating. Page G-3A shows wired glass in steel-sash windows would permit a separation distance of about 15 feet and would provide satisfactory protection.

Blank masonry walls provide satisfactory protection for exposures to Sides A and C.



NOTE: Blank Masonry Walls indicated by heavy lines

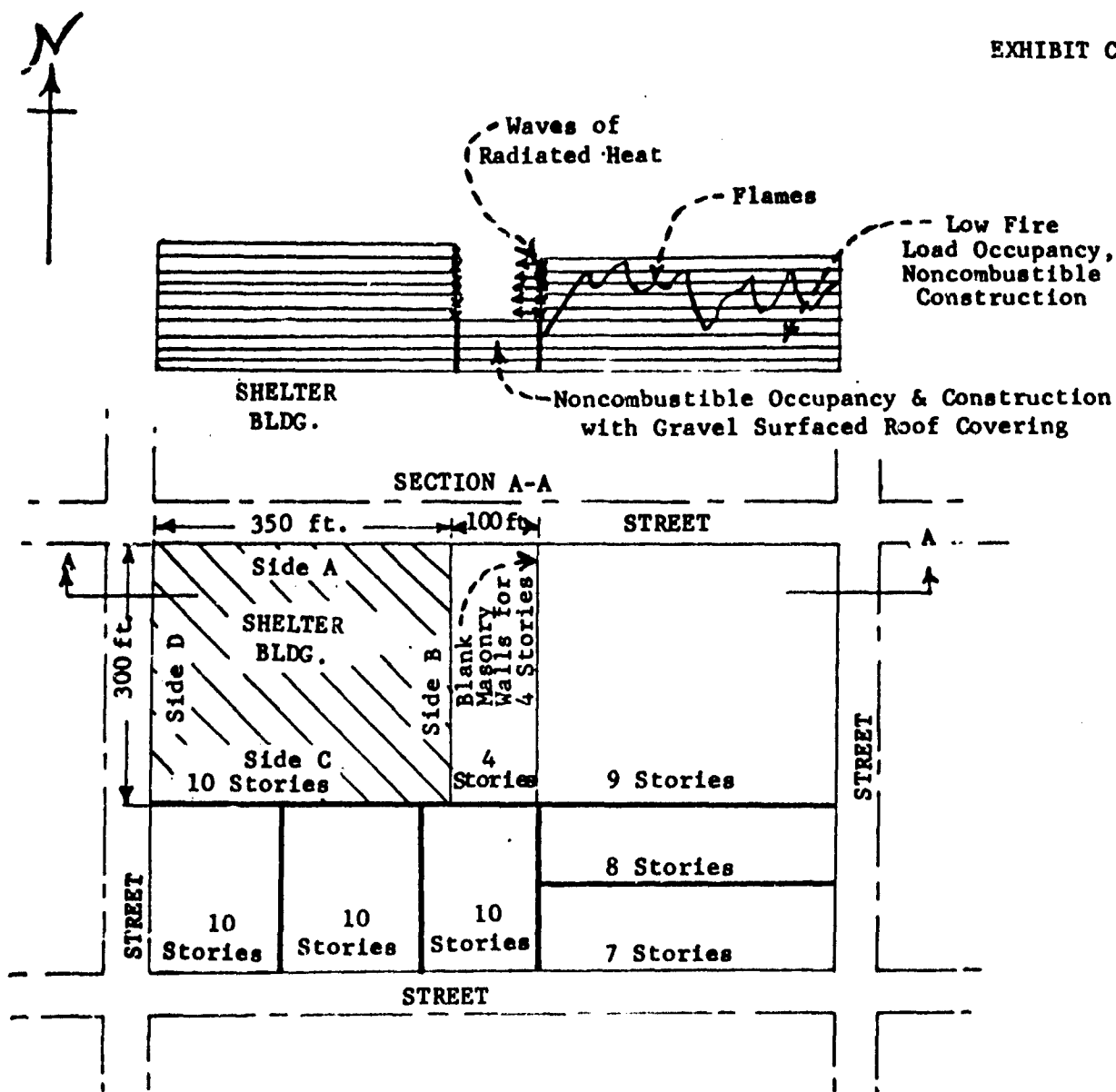
ZONE 3 - EXPOSURE ANALYSIS:

Exposure to be considered to Side D consists of Buildings "A" and "B". Since the wall between these two buildings is not a blank masonry wall, consider the two buildings as one. Although the total wall length of these two buildings is 400 ft., an angle of 45° is taken from the southwest corner of the Shelter Building to determine the length of the effective heat-radiating face. This procedure gives a wall length of 220 ft.

The Fire Loading is based on the more severe of Buildings "A" and "B", i.e., "High." Wall length is effectively 220 ft. and Separation Distance is 20 ft.

The Alignment Diagram on Page G-2 is used for a 3-story building which shows that a Separation Distance of approximately 180 ft. is needed. Thus the 20-ft. distance results in a "Class D" shelter rating. Page G-2A shows wired glass in steel-sash windows also to fall in this class; and, therefore, fire shutters, or doors, or a blank masonry wall is required.

Blank masonry walls provide satisfactory protection for exposures to Sides A and C.



- NOTES: (1) Blank Masonry Walls indicated by heavy lines—
 (2) Unprotected Openings; such as Windows, Ordinary Doors, or Wood Wall Sections, indicated by "X".

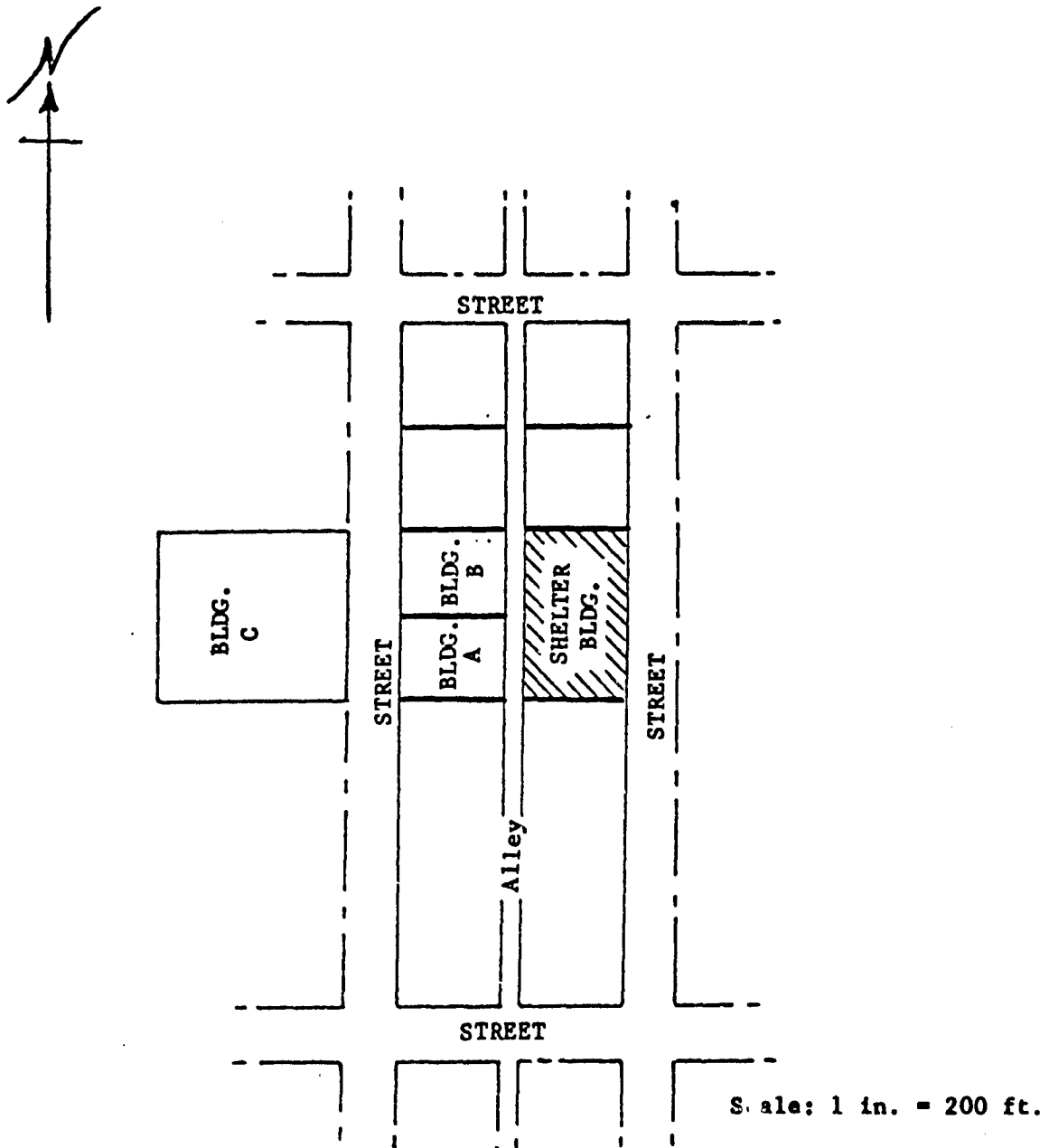
ZONE 3 - EXPOSURE ANALYSIS

Four-story building to the east presents no exposure hazard to Side B. Shelter Building "sees" radiated heat only from top five stories of 9-story building to the east, so this is only exposure to Side B which needs to be considered.

Considering the top five stories of the 9-story building, the Alignment Diagram for a 5-story building is used on Page G-3. A separation distance of 100 feet results in a "Class D" shelter rating, but Page G-3A shows wired glass in steel-frame windows will result in a "Class A" shelter rating.

Blank masonry walls provide satisfactory protection for exposure to Side C (south side).

EXHIBIT D



NOTE: Blank Masonry Walls indicated by heavy lines ———

ZONE 3 - EXPOSURE ANALYSIS:

The sketch indicates exposure to the Shelter Building need only be considered from the west.

At first glance it appears that either, but not both, Building A or Building B should be evaluated for exposure since there is a blank masonry wall between Buildings A and B. However, assuming Building C has factors (fire loading, etc.) to radiate sufficient heat across the street to ignite both Buildings A and B, the total wall length of Buildings A and B must be considered as exposing the Shelter Building. The analysis is then made as in Exhibit B.

<p>DDC NO.</p> <p>FACTORY MUTUAL RESEARCH CORPORATION, Norwood, Massachusetts</p> <p>FIRE HAZARD TO FALLOUT SHELTER OCCUPANTS: A CLASSIFICATION GUIDE by J. B. Smith, E. W. Cousins and R. M. Newman Research Report, April 3, 1964, 6 pp., Appendix 15 pp. illus. tables 17 ref. UNCLASSIFIED</p> <p>FMRC Serial No. 15328, Contract No. OCD-PS-64-40, Subtask 1133A</p> <p>A method of classifying the hazard from fire to occupants of fallout shelters is presented. It represents, in the form of a simple survey, a conservative fire-protection-engineering approach with a high confidence factor. The intention of this study is not to relate fire safety to weapons effects; instead it addresses the problem that should fires occur - from any cause - would the occupants of a particular fallout shelter be safe from fire? Further, the guide does not attempt to define the relative degrees of hazard, or proba-</p>	<p>UNCLASSIFIED</p> <ol style="list-style-type: none"> 1. Shelters 2. Fire Safety 3. Analysis 4. Classification 5. Acceptability 6. Buildings 7. Structures 8. Construction 9. Vulnerability 10. Standards
<p>DDC NO.</p> <p>FACTORY MUTUAL RESEARCH CORPORATION, Norwood, Massachusetts</p> <p>FIRE HAZARD TO FALLOUT SHELTER OCCUPANTS: A CLASSIFICATION GUIDE by J. B. Smith, E. W. Cousins and R. M. Newman Research Report, April 3, 1964, 6 pp., Appendix 15 pp. illus. tables 17 ref. UNCLASSIFIED</p> <p>FMRC Serial No. 15328, Contract No. OCD-PS-64-40, Subtask 1133A</p> <p>A method of classifying the hazard from fire to occupants of fallout shelters is presented. It represents, in the form of a simple survey, a conservative fire-protection-engineering approach with a high confidence factor. The intention of this study is not to relate fire safety to weapons effects; instead it addresses the problem that should fires occur - from any cause - would the occupants of a particular fallout shelter be safe from fire? Further, the guide does not attempt to define the relative degrees of hazard, or proba-</p>	<p>UNCLASSIFIED</p> <ol style="list-style-type: none"> 1. Shelters 2. Fire Safety 3. Analysis 4. Classification 5. Acceptability 6. Buildings 7. Structures 8. Construction 9. Vulnerability 10. Standards
<p>DDC NO.</p> <p>FACTORY MUTUAL RESEARCH CORPORATION, Norwood, Massachusetts</p> <p>FIRE HAZARD TO FALLOUT SHELTER OCCUPANTS: A CLASSIFICATION GUIDE by J. B. Smith, E. W. Cousins and R. M. Newman Research Report, April 3, 1964, 6 pp., Appendix 15 pp. illus. tables 17 ref. UNCLASSIFIED</p> <p>FMRC Serial No. 15328, Contract No. OCD-PS-64-40, Subtask 1133A</p> <p>A method of classifying the hazard from fire to occupants of fallout shelters is presented. It represents, in the form of a simple survey, a conservative fire-protection-engineering approach with a high confidence factor. The intention of this study is not to relate fire safety to weapons effects; instead it addresses the problem that should fires occur - from any cause - would the occupants of a particular fallout shelter be safe from fire? Further, the guide does not attempt to define the relative degrees of hazard, or proba-</p>	<p>UNCLASSIFIED</p> <ol style="list-style-type: none"> 1. Shelters 2. Fire Safety 3. Analysis 4. Classification 5. Acceptability 6. Buildings 7. Structures 8. Construction 9. Vulnerability 10. Standards
<p>DDC NO.</p> <p>FACTORY MUTUAL RESEARCH CORPORATION, Norwood, Massachusetts</p> <p>FIRE HAZARD TO FALLOUT SHELTER OCCUPANTS: A CLASSIFICATION GUIDE by J. B. Smith, E. W. Cousins and R. M. Newman Research Report, April 3, 1964, 6 pp., Appendix 15 pp. illus. tables 17 ref. UNCLASSIFIED</p> <p>FMRC Serial No. 15328, Contract No. OCD-PS-64-40, Subtask 1133A</p> <p>A method of classifying the hazard from fire to occupants of fallout shelters is presented. It represents, in the form of a simple survey, a conservative fire-protection-engineering approach with a high confidence factor. The intention of this study is not to relate fire safety to weapons effects; instead it addresses the problem that should fires occur - from any cause - would the occupants of a particular fallout shelter be safe from fire? Further, the guide does not attempt to define the relative degrees of hazard, or proba-</p>	<p>UNCLASSIFIED</p> <ol style="list-style-type: none"> 1. Shelters 2. Fire Safety 3. Analysis 4. Classification 5. Acceptability 6. Buildings 7. Structures 8. Construction 9. Vulnerability 10. Standards

<p>bility of hazard, for non-sprinklered shelter buildings which are not unequivocally considered safe. Assuming that fires from any cause have occurred following a nuclear attack; that there is no "fire storm"; that there will be no fire fighting by public fire department; that public water supplies and electric utilities will be in service; and that automatic sprinklers - as available - will be in service, the fire hazard to shelter occupants is analyzed. Safe separation distances between buildings were determined from British work and some conservative simplifying assumptions. A manual, "Fire Hazard to Fallout Occupants: A Classification Guide," was prepared for the use of architects and engineers. The guide was field-tested by several architects and a consulting engineer. Trial surveys were made at existing designated shelters in buildings of varied construction, occupancy, and age, in relatively congested areas. In general, the guide was found to be simple and easy to use. Consistent results were obtained.</p>	<p>UNCLASSIFIED</p>	<p>UNCLASSIFIED</p>	<p>bility of hazard, for non-sprinklered shelter buildings which are not unequivocally considered safe. Assuming that fires from any cause have occurred following a nuclear attack; that there is no "fire storm"; that there will be no fire fighting by public fire department; that public water supplies and electric utilities will be in service; and that automatic sprinklers - as available - will be in service, the fire hazard to shelter occupants is analyzed. Safe separation distances between buildings were determined from British work and some conservative simplifying assumptions. A manual, "Fire Hazard to Fallout Occupants: A Classification Guide," was prepared for the use of architects and engineers. The guide was field-tested by several architects and a consulting engineer. Trial surveys were made at existing designated shelters in buildings of varied construction, occupancy, and age, in relatively congested areas. In general, the guide was found to be simple and easy to use. Consistent results were obtained.</p>
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